...ENTATION PAGE

Form Approved
OMB No. 0704-0188

...DATE	3. REPORT TYPE AND DATES COVERED
	ANNUAL 15 Nov 90 To 14 Oct 91

4. TITLE AND SUBTITLE
LOCATION AND CHARACTERIZATION OF IN-CLOUD LIGHTNING CURRENTS BY MULTIPLE STATION VHF AND ELECTRIC FIELD MEASUREMENTS

5. FUNDING NUMBERS
GR - AFOSR-91-0093
PE - 61102F
PR - 2310
TA - CS

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AFOSR-TR- 92 0125

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Building 410
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10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A network has been established that measures and records electric fields in a 600 Hz to 3.5 MHz 3dB bandwidth at five stations at Kennedy Space Center. Signals were recorded at the central station with a 20 MS/s digitizing system that operating on a 24 hour per day basis. Data has been obtained from both lightning and small discharges that do not fit the commonly accepted definition of "lightning". These small discharges frequently precede the first cloud-to-ground flash in a storm and are the most significant finding in the research so far. They have considerable importance in the field of thunderstorm electrification in that they predominantly occur below the freezing level, at a mean height of about 3-4 km.

14. SUBJECT TERMS			15. NUMBER OF PAGES
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITIED

Annual Technical Report

Date 12/14/91

Title Location and Characterization of In-Cloud Lightning Currents by Multiple Station VHF and Electric Field Measurements

PI Ewen M. Thomson, University of Florida

Grant Number AFOSR-91-0093

Summary

A network has been established that measures and records electric fields in a 600 Hz to 3.5 MHz 3dB bandwidth at five stations at Kennedy Space Center. Signals were recorded at the central station with a 20 MS/s digitizing system that operating on a 24 hour per day basis. Data has been obtained from both lightning and small discharges that do not fit the commonly accepted definition of "lightning". These small discharges frequently precede the first cloud-to-ground flash in a storm and are the most significant finding in the research so far. They have considerable importance in the field of thunderstorm electrification in that they predominantly occur below the freezing level, at a mean height of about 3-4 km.

Research Objectives

The overall purpose is to understand better the physics of in-cloud lightning processes that give rise to radiation pulses in the electric field record and to investigate the potential use of this radiation to provide early warning of thunderstorm activity.

The main scientific objectives are:-

(a) To establish the location and characteristics of initial discharge processes in both cloud and ground flashes;

(b) to identify, locate, and characterize any wideband events not

associated with lightning but radiated from electrified clouds;

(c) to test the hypothesis of Weidman and Krider that the small pulses riding on the leading edge of large bipolar pulses are associated with channel formation;

(d) to test the commonly accepted hypothesis that K changes result from in-cloud streamers that propagate along pre-existing channels;

(e) to investigate the relationship between in-cloud current properties and thunderstorm activity as reflected in the flashing rate;

(f) to trace the location, channel orientation and current polarity of rapid discharge processes in intracloud flashes to determine whether the preferred mechanism involves negative or positive charge;

(g) to locate and characterize the narrow pulses previously detected, but not located, by Le Vine and Willett.

Status of the Research

Significant progress has been made towards all major objectives in that the system is now operational and has recorded high quality data simultaneously with radar and lightning interferometric data obtained by Dr. Krehbiel of New Mexico Institute of Mining and Technology. Data organization and analysis is now in progress.

Our initial emphasis, after performing calibrations, was to study the narrow bipolar pulses as described in Objective (g) and relevant to Objective (b). These were particularly interesting as they frequently appeared to occur very early in the thunderstorm life cycle and hence had obvious relevance to our overall objective of finding radiated signals of use in thunderstorm early detection and warning. The locations of the origins of these pulses were completely unexpected. Since the most widely accepted theory for thunderstorm electrification involves interaction between hydrometeors of different phase, for example, liquid water and graupel, one might expect to find manifestations of early charging above the freezing level perhaps at a height of 7-8 km asl which is near the -10 deg C isotherm and the height where most lightning researchers consider the main negatively charged region to be.

Instead we located the origin of the narrow pulse at heights of 3 km to 6 km, compared with an ambient atmosphere freezing level of about 5 km asl. Thus liquid water must be the predominant hydrometeor phase.

Articles Planned for Publication

No articles have been published concerning the research. However, several are planned:-

(i) Title: E and dE/dt waveshapes for narrow pulses radiated from thunderstorms
Authors: Medelius, Thomson, Pierce
Journal: Journal of Geophysics Research

(ii) Title: The effect of a propagating source region on the narrowband VHF radiation received at spatially separated stations
Authors: Thomson, Medelius
Journal: Journal of Geophysics Research

(iii) Title: The amplitude spectra of narrow pulse width radiation electric fields from thunderstorms in a 180 MHz bandwidth
Authors: Medelius, Thomson
Journal: Journal of Geophysics Research

(iv) Title: Narrow bipolar electric field pulse locations in an immature thunderstorm
Authors: Medelius, Thomson
Journal: Geophysics Research Letters

Participating Professionals

Ewen Thomson, Associate Professor
Martin Uman, Professor
Jamie Stone, Scientific Programmer

Conference Presentations

(a) International Conference on Lightning and Static Electricity, Cocoa Beach, FL, March 1991

Title: A system for multiple station measurement of wideband electric field and VHF radiation from lightning at Kennedy Space Center
Presenter: Thomson

Title: E and dE/dt waveshapes from initial phases of close lightning at Kennedy Space Center
Presenter: Medelius

(b) American Geophysical Union Fall Meeting, San Francisco, December 1991

Title: Multiple station lightning electric field measurements
Presenter: Medelius

Other Interactions

Subject matter: Future of the rocket triggered lightning research program at Kennedy Space Center
Location: University of Florida
Date: December 9, 1991
Names and affiliation: Bill Jones and William Jafferis, Kennedy Space Center

New Discoveries and Applications

The observation that narrow bipolar pulses are radiated during early electrification and from below the freezing level is a novel finding of significant importance for thunderstorm forecasting and monitoring as well as for basic science. The multiple station network is now permanently installed at Kennedy Space Center under the on-site control of Pedro Medelius and is available for operational use by KSC.

Ancillary Information

The task attempted in the first year of the grant - to develop, set up, test and take data with a five station wideband electric field system - was exceedingly ambitious. Our reliance on NASA, through a contract with Boeing, to provide all microwave links, fiber optic links and ground planes was especially tentative. To place this undertaking in perspective, it took about five years for NASA to procure, test and setup the microwave links used for two of the stations in the experiment. Despite numerous logistical glitches, all five data links are now operational. Not only did we get data of very high quality, but we also received a bonus in that Pedro Medelius was employed by Boeing to manage the multiple station network and obtain data on a continuous basis. Although we missed out on the bulk of CAPE, there was a time lag between CAPE and all of the lightning experiments and we did manage to get simultaneous data from four stations, the minimum required to get a 3D fix, with NMIMT and CP-2 radar. These were the most important joint experiments.